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54. Process and device for the improvement of night vision, notably for motor vehicles.

57. The invention concerns a process of improvement of night vision, notably for motor vehicles, consisting by means of an image recording system sensitive to visible and non-visible rays, to capture an image of the roadway, illuminated by headlights emitting in the ranges of visible and/or non-visible wavelengths, the said image being constituted of pixels, elementary points each having a gray level and to apply the said image to an LUT, law of transformation of gray levels, characterized in that at least two different laws of transformation are applied to distinct groups of pixels of the image.

The invention also concerns a device for the implementation of the process of improvement of night vision previously described.

Application to aiding night vision for motor vehicles.

The present invention concerns a process and a device for the improvement of night vision, notably for motor vehicles.

It has been observed that long-range headlights are in practical terms very little used since their usage is limited to little-traveled roads due to their dazzling effect.

Furthermore, high beam lights having a limited range, do not allow one to clearly distinguish obstacles close to the vehicle, which leaves the driver very little time to react and undertake an evasive maneuver.

Therefore, systems have already been proposed, notably in document EP-A-O 505 237, to aid night vision which include headlight emitting rays of non-visible wavelengths (infra-red or ultraviolet), as well as cameras sensitive to these rays and which collect images of the vehicle's surroundings, these images being visualized in real time in the vehicle by the driver.

Notably, through document EP-A-0 454 516, an approach which combines the image coming from a camera sensitive to infrared rays to that of a camera operating in the visible range, to form a single image, is also known.

However, this type of image of the nocturnal surroundings does not provide a very natural perception of the environment and has zones of highly variable contrast and intensity.

It is known, in addition, that in a general way, CCD sensors (charge coupling devices, used in cameras for improving vision, produce images that are not faithful to the natural visual perception of the landscape. In effect, the perception of contrasts by the human eye is more logarithmic whereas CCD sensors are more or less linear.

This problem with CCD sensors is usually corrected by applying a gray level conversion table, LUT, or Look-Up Table, to the signal produced by the said sensors.

This principle can also be applied in order to improve the image contrast of the nocturnal surroundings as mentioned in document EP-A-O 454 516.

But these treatments do not give very satisfactory results due to the nature of the images of the nocturnal surroundings, which are very dark in zones that are not illuminated by the vehicle's headlights and very bright in the illuminated zones of the image.

A principal aim of the present invention is to solve the above-mentioned problems.

To this effect, the present invention concerns a process and a device for improving night vision, notably for motor vehicles, free of the disadvantages of the previous technique.

The process for improving night vision, notably for motor vehicles, according to the invention, consists, by means of an image recording system sensitive to visible and non-visible rays, to capture an image of the roadway, illuminated by headlights emitting in the visible and non-visible ranges of the spectrum, the said image being constituted of pixels, elementary points each having a gray level and apply a LUT, law of the transformation of gray levels, to the said image. It is notably characterized in that at least two different laws of transformation are applied to distinct groups of pixels of the image.

By using the process according to the invention, a specific treatment can be applied to different zones of contrast and light, very different[1] that are encountered in an image of nocturnal surroundings illuminated by the vehicle headlights, in such a way as to obtain, after the said treatment, an image which is close to that of natural human perception.

According to another aspect of the invention, the roadway is illuminated, on the one hand, by a headlight emitting in the visible range of the spectrum, and, on the other hand, at least one headlight emitting in the infrared range, the image recording system including an image capturing means that is sensitive to the visible and infrared ranges of the spectrum.

The infrared image recording system allows for the detection of objects in zones that are not usually illuminated by the high beam lights of vehicles.

In a variation of the invention, a headlight emitting in the ultraviolet range can also be used, associated with an image capturing means that is sensitive to the ultraviolet spectral range.

According to another characteristic of the invention, a law of transformation of specific gray levels is applied to each line of the captured image.

Due to this characteristic, the borders of the treated zones are not visible in the image obtained after treatment according to the invention.

According to another characteristic of the invention, the law of transformation associates, at each gray level g of a pixel of the captured image, a gray level g′ such that:

$$g' = f(g, x, y) = G(x, y)\,(1 - e^{-k(x, y)\,g}) \text{ or}$$
$$g' = 1 \text{ if the preceding result is greater than } 1,$$

where x and y are the coordinates of the pixel in the image and where G(x, y) and k (x, y) are parameters characterizing the said transformation and are dependent on coordinates x and y of the pixel in which the above is applied.

Thus, a specific treatment of each pixel of the image is applied.

According to another aspect of the invention, the law of transformation associates, at each gray level g of a pixel of the captured image, a gray level g′ such that:

$$g' = h(g, y) = S(y)\,(1 - e^{-t(y)\,g}) \text{ or}$$

[1] IL Note - Meaning of source language unclear. Literal translation is provided.

$g' = 1$ if the preceding result is greater than 1,

where y is the ordinate of the pixel in the image and where S(y) and t(y) are parameters characterizing the said transformation and dependent on the ordinate y of the pixel to which this is applied.

Thus, a specific treatment is applied to each line.

According to another characteristic of the invention, the law of transformation of gray levels is dependent on a setting parameter, the said parameter being independent of the coordinates of the pixel to which the said law of transformation is applied.

The invention also concerns a device to improve night vision for the implementation of the process according to one of the characteristics described previously, of a type including a camera equipped with CCD sensors and a piloting module of the said sensors. The device is notably characterized in that it has a memory containing all possible values, which are predetermined, of the law of transformation of gray levels.

According to another aspect of the invention, the storage address for each g′ value, an image, by the transformation h of a gray level g of a pixel located at coordinates x and y of the image, is formed by the concatenation of the following digital signals:

- the gray level g of the pixel, and
- the ordinate of the said pixel.

According to another aspect of the invention, the said address integrates the abscissa (x) of the said pixel during its formation.

According to another aspect of the invention, the said address integrates a setting parameter of the said transformation during its formation.

According to other characteristics of the invention:
-the said device includes a line counting circuit delivering, for each pixel of the image, the ordinate of the said pixel.
-the said device includes in addition a column counting circuit delivering, for each pixel of the image, the abscissa (x) of the said pixel.
-the said device includes a micro-controller delivering the setting parameter of the transformation.

Other characteristics and advantages of the invention will become clear in the following description of several possible ways of implementing the invention and with reference to the attached illustrations, among which:

-Figure 1 schematically represents an image of nocturnal surroundings illuminated by the headlights of a vehicle emitting in the visible domain of the spectrum and that of the infrared;
-Figure 2 represents a transformation of gray levels of the image from Figure 1 in accordance with a possible form of execution of the invention;
-Figure 3 schematically illustrates the first form of execution of the invention;
-Figure 4a, 4b, and 4c illustrate the principle of the calculation of a new gray level by a LUT according to the first form of execution of the invention;
-Figure 5 schematically illustrates the treatment zones of an image of nocturnal surroundings, illuminated by the headlights of a vehicle, according to a second form of execution of the invention;
-Figure 6 schematically illustrates the second way of implementing the invention.

In Figure 1, image 1, of nocturnal surroundings illuminated by a vehicle's headlights that could be picked up by a camera of a visual aid system, is represented.

Such an image is composed of a certain number of pixels, elementary points of the image, which are located via the coordinates abscissa x and ordinate y, with each having its own gray level g.

Lane 2, which the vehicle is travelling on, is drawn with dots, bordered on the left by a flat zone 3 and on the right by an embankment 4.

Four zones of variable contrast and intensity can be distinguished in this image. Zone A is closest to the vehicle and is the one with the highest illumination from the high beam lights. This zone is bright and strongly contrasted, it is therefore not of much interest for visual aid systems since potential obstacles present in this zone are clearly visible to the naked eye.

Zone B corresponds to the edge of the range of the high beam lights. This zone is therefore dark and weakly contrasted. It is to be noted that line 5 of the limit between zones A and B do not have the same shape on the left side of the image, corresponding to a flat part 3 of the edge of lane 2, that on the right of the image corresponds to an embankment 4 located art the other edge of lane 2.

Zone C corresponds to the zone which is illuminated by infrared rays. It is dark but it can be more contrasted than zone B when obstacles are present. This zone is also that which is illuminated by the long-range headlights when they are activated. Line 6 is the limit between zones B and C and has more or less the same shape as line 5 which is the limit between zones A and B.

Zone D is the farthest from the vehicle and it is not illuminated by the headlights nor the turning signal lights since it is of little interest for driving. It corresponds more or less to the landscape, the sky and all that is beyond the roadway upon which the vehicle is travelling. It is therefore very dark and there can be significant noise in the signal delivered by the camera for the points of the image located in this zone.

The line of limit 7 between zones C and D more or less follows the lines of escape to the horizon of lane 2 with a significant gap towards the right of the said lane.

In the image, as described in Figure 1, two zones B and C therefore exist that are of interest to treat in order to increase contrast and brightness, since an anticipated detection of obstacles present in these zones can allow the driver to execute avoidance maneuvers more effectively.

Image 1 of Figure 1 can therefore be segmented into zones (A, B, C and D) of variable interest and as the contrast and brightness are very different in each of these zones, a treatment according to the invention consists in applying LUTs specific to each zone of the image in order to improve the driver's perception.

It could however be that the LUTs best adapted to the different zones are more or less different one from another, and that the application of the described treatment of an image like that of Figure 1 makes limits appear between the treated zones.

In this case, so that the limits between the zones are not visible, the treatment according to the invention can be applied on groups of pixels of smaller size than zones A, B, C and D described previously, in particular a LUT can be applied which is specific for each pixel of the image, for example.

In Figure 2, the curve 8 of the transformation of gray levels of a LUT is represented according to an example of the implementation of the invention.

This LUT transforms a gray level g, included in the implementation example between 0 and 1, of a pixel located at coordinates (x, y) of the image, at a gray level:

$g' = f(g, x, y) = G(x, y)\,(1 - e^{-k(x, y)\,g})$ *or,*
$g' = 1$ if the preceding result is greater than 1,

where G(x, y) and k(x,y) are parameters that characterize transformation f and that, according to the invention, are dependent on coordinates (x, y) of the pixel to which the said transformation is being applied..

This type of transformation f, represented by curve 8, executes a logarithmic correction of the image by increasing the contrast more in the dark zones than in the bright zones, which gives the said image an appearance which is closer to the natural perception of the human eye.

The derivation of function f in relation to g,

$$\frac{df}{dg} = k(x, y)\, G(x, y)\, e^{-k(x, y)\, g},$$

characterizes the modification of the contrast of the image.

In figure 2, straight line 9 is represented, which is tangential to curve 8 at the origin (0,0) of the location, and has a slope k(x, y) G(x, y) which corresponds to the derivation of f in relation to g at the origin, that is to say for g=0.

This line 9 has a slope greater than 1, which means that, in the dark zones of the image (those which have gray levels close to 0), the contrast is increased by transformation f.

A second line 10, tangential to curve 8 in 11, for a gray level corresponding to g^{*2}, has a slope (derivation f in relation to g for g=g') equals 1, which means that, in the zones of the image having a gray level equal to g*, the contrasts are not modified by transformation f.

A third line 12, tangential to curve 8 in 13, which corresponds to the gray level g+1, has a slope (derivation of f in relation to g for g=1) far below 1, which means that, in the brighter zones of the image (those whose gray levels are close to 1) the contrast is lowered by transformation f.

The parameters G(x, y) and k(x, y) are dependent on coordinates (x, y) of the pixel to which the LUT is applied, a specific transformation f can be applied to each pixel of the image, whose parameters G(x, y) and k(x, y) characterize the improvement of the contrast for dark gray levels and determine the gray level g*, from which the contrast is lowered.

Obviously, these parameters can be identical for several pixels of the image located at different x and y coordinates, in such a way as to make specific corrections to groups of pixels of the image.

Thus, according to the invention, the correction of gray levels is not performed in a uniform manner across the entire image, but is specific to each pixel or group of pixels in such a way as to optimize the said correction following the contrast and brightness of the said pixel or group of pixels.

In Figure 3, a form of execution of the transformation f described above is represented.
In this diagram, only the relationships useful in the understanding of the invention are represented. For example, the connections to supplies and to configuration pins of processors have not been mentioned.

A camera 20 equipped with a matrix of CCD sensors 21, of a size of 256x256 pixels, for example, is controlled by a piloting module 22 of CCD sensors.

The said camera 20 delivers an analog video signal which contains analog gray levels of pixels of the captured image and which is directed to the input of the analog-digital converter (ADC) 24, the said converter providing a digital signal 25 at the output containing the gray levels g, digitized on k bits.

If the CCD sensor is of 256x256 pixels in size and it operates at the video rate of 25 images per second, the frequency of the arrival of gray levels in the converter 24 is greater or equal to 1.6 MHz. A signal processor that can handle such a flow of data is therefore required.

The digital signal processors (DSP) are able to operate at rates greater than 1.6 MHz and in a variation of the invention which is not represented, such a processor could be used to execute transformation f by means of a program integrated in the said processor.

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[2] IL Note - Illegible subscript symbol in the original text due to the poor quality of the copy.

In the case of Figure 3, the transformation f is performed via a hard-wired circuit which allows a slower and therefore less expensive processor to be used such as the microcontroller 26.
The said microcontroller 26 operates at a slower rate than that typically supplied by a CCD sensor camera, it is adapted to control the said camera and to work on memorized sequences of images at a lower rate.

The microcontroller 26 supplies, from an output 41, a signal 27 controlling the period the camera is open and a signal 28 giving a reading pip of the CCD sensors for each image, the said signals 27, 28 being directed to the input of a first control module 29 of the pilot 22 of the CCD sensors.

The control module 29 has an output 30 directed to the input of a clock signal generator 31, the said generator returning the pips of the clock to control module 29 by means of a signal 32, issuing from n output of generator 31 and entering by an input 36 in the control module 29.

The said control module 29 also has an output 37 delivering video synchronization signals 38, and line synchronization and frame synchronization signals, the said signals being used to control a viewing monitor for the image, once it has been treated.

The clock signal generator 31 has a second output supplying clock signals 33, the said signals entering a final module 34 of the pilot of the CCD sensors 22. This module 34, whose output is directed to the input of a matrix of CCD sensors 21, serves as an interface with the said matrix executing, among other things, an adaptation of the impedance levels.

Together, modules 29, 31, and 34, previously described, make up the pilot 22 of sensors of the matrix 21.

The clock signals 33 from generator 31 are divided into two types of signal: a signal 39 that has a wave front (rising or descending) at each new line of the image, and a signal 40 with a wave front switching at each new pixel of a line.

The pixel clock signal 40 is hooked up to an input 40a of the analog converter by supplying a clock pip for each new pixel to the converter, the said clock pip triggering the digitization of a pixel.

The pixel clock signal 40 is also hooked up to input 40b of a column counter circuit 42. This circuit receives a clock pip for each new pixel and it increments, at each pip, a column counter. The information of the column number makes it possible to know the coordinates of abscissa x (referring to the notation used in Figure 1) of each pixel.

The column counting circuit 42 also receives the line clock signal 39 at its input 39b, which provides a clock pip with each new line of the image, the said clock pip triggering the setting of the column counter back to zero.
At the output of the column counting circuit 42, a signal 44 containing the abscissa x of a pixel, digitized on m bits is delivered.

The line clock signal 39 is also hooked up to the entry 39a of a line counting circuit 43. This circuit receives a clock pip for each new line of the image and it adds a line, with each of the pips to a line counter. This information on the line number makes it possible to know the coordinate y (referring to the notation used in Figure 1) of each pixel.

The line counting circuit 43 also receives at its input 47, the signal 28 issuing from the microcontroller 26, which supplies a clock pip for each new image, the said clock pip triggering the setting of the line counter back to zero.

At the output of line counting circuit 43, a signal 45 containing the ordinate y of a pixel, digitized on 1 bits is delivered.

The signals 44, containing the coordinate x on m bits and 45, containing the coordinate y on l bits are fused, in a known manner, into a signal 46 formed by the concatenation of the x and y data and digitized on m-l bits.

Signal 46 is then concatenated with signal 25, produced by generating the analog-digital converter 24 and containing the gray level g digitized on k bits to form signal 48 containing the x , y, and g data digitized on k+l+m bits.

The said signal 48 contains the information g, x, and y necessary for the application of the transformation f of the gray levels described in Figure 2.

However, an additional parameter p, produced by generating microcontroller 26, can be used in such a way as to parametrize transformation f. For example, a different treatment can be applied in the case where the image is taken at sundown and in the case where it is taken in the middle of the night.

A signal 49, issuing from the output 50 of microcontroller 26, contains the said parameter p, digitized on n bits and concatenates with signal 48, previously described, to form signal 51 containing the g, x, y and p data digitized on k+l+m+n bits.

The said signal 51 is then applied at the input of a LUT 52 which transforms the initial gray level g into a new gray level g′, following the previously described transformation f, the said gray level g′ being digitized on k′ bits in the signal of output 53 of LUT 52.

The principle of the calculation of the new gray level g′ by LUT 52 can be better understood by referencing Figures 4a to 4c.

In Figure 4a, an image 60 is represented such that it could be obtained by the matrix of CCD sensors from a camera such as 20 described in Figure 3. On this image a particular pixel 61 is drawn, located in the image at the point of coordinates {x, y} and having a gray level g.

From these data one can, according to Figure 3, obtain a signal 51 containing the g, x, y, and p data digitized on k+l+m+n bits. The said signal 51 serves to form, for each pixel of the image, an address according to the table in Figure 4b, that is to say by concatenating the k bits of gray level g of the said pixel with l bits of ordinate y, the m bits of abscissa x and the n bits of parameter p.

The address thus formed is sent to a memory 62 of a ROM type (Read Only Memory) represented in Figure 4c. At the corresponding address 63 of the said memory, the value of the image by the transformation f (parametrized by p) of the g, x, y, and p data contained in the address , $f_p(g, x, y)=g'$ is stored.

The memory 62 is of a sufficient size to contain the values of images by the transformation f of all the possible combinations of the g, x, y, and p data.

The gray level g′ , digitized on k′ bits, constitutes the output signal 53 of LUT 52 in reference to Figure 3.

Figure 3 illustrates an image storage memory 54, the said memory being of a RAM type (Random Access Memory) intended to memorize the frames of the image in such a way that the microcontroller 26, working at a lower rate than that of the video signal emitted by the matrix of the CCD sensors, can work on the frames of memorized images at a lower rate.

The said image memory 54 receives at its input 58 the signal 25 (represented here by the dotted 25′) containing the gray level g of each pixel just as it is captured by the matrix of CCD sensors 21. In addition, it receives, at its input 59, the signal 46 (represented here by the dotted 46′) containing the line and column numbers of the said pixel, that is to say its x and y coordinates (according to the notation in Figure 4a).

In addition, memory 54 is hooked up to microcontroller 26 by means of a data bus 55, conveying the gray levels g of each pixel and an address bus, conveying the line and column numbers of each pixel.

At the output of the overall circuit described in Figure 3, is signal 53, containing the transformed gray levels g′ digitized on k′ bits, and video synchronization signals 38. These signals 53, 38 can then be sent to a viewing monitor after digital-analog conversion of gray levels g′.

In a variation of the form of execution for this invention presented in Figure 3, module 57, drawn with dots, can be omitted, by replacing microcontoller 26 with a clock signal generator delivering signals 27 controlling the time period the camera is open, and 28 giving reading pips of the CCD sensors with each image. In this case, the relationships drawn with dots 25′, 46′ , and 49 can all be also omitted.

In a second variation of the implementation method for this invention, only the parametrizing of transformation f, that is to say parameter p, issuing from output 50 of the microcontroller 26 and conveyed by signal 49 is omitted.

Figure 5 illustrates an image 101 of nocturnal surroundings illuminated by headlights of a vehicle similar to that of Figure 1.

Zones A, B, C, and D of the segmentation of the image described in Figure 1 are found in image 101, the limits of the said zones have been represented here with discontinuous lines.

In addition, the lane in which the vehicle is traveling is represented by the dotted area 102.

Since zone D, located above the limit line 107 is of little interest for the driver of the vehicle and that, consequently, its pixels do not require a specific treatment, and that additionally, the other zones A, B, and C are separated by more or less horizontal limits, it could be worthwhile to approximate the said zones A, B, C and D with zones A′, B′, C′, and D′, the latter being separated by limits 105, 106, 108 which are parallel lines at the axis of abscissa x.

With a segmentation of the image of this type that is purely horizontal, a simpler transformation of gray levels can be applied, that does not take the initial gray level of the pixel and the ordinate y of the said pixel into account and which no longer takes abscissa x of the pixel into account as in the transformation previously described.

As an example, a transformation h can be applied, which for any gray level g of a pixel having an ordinate y which is associated with a gray level:

$$g' = h(g, y) = S(y)\,(1 - e^{-t(y)\,g}) \text{ or}$$
$$g' = 1 \text{ if the preceding result is greater than 1,}$$

Where S(y) and t(y) are parameters which characterize the transformation h and which are dependent on ordinate y (or line number) of the pixel to which the said transformation is applied.

Figure 6 illustrates a second form of execution of the invention according to the principle explained above.

In this diagram, the essential elements of Figure 3 are illustrated, with similar references and one can refer to the description of the said Figure 3 in order to understand the diagram.

The principal difference between this diagram and Figure 3 lies in the fact that the present diagram no longer has the column counting circuit. In effect, since the transformation h of this form of execution of the invention does not take abscissa x of the pixel into account, as it is applied, it is no longer necessary to know the column number of the said pixel.

Consequently, the signal 48 is, in this application, constituted by the concatenation of gray level g, coming from signal 25, with ordinate y, coming from signal 45 and the said signal 48 is digitized on k=l bits. Likewise, signal 51 contains, in this application, the initial gray level g of a pixel, the ordinate y of the said pixel and a parameter p serving to parametrize transformation h, the said signal being digitized on k+l+n bits.

Another difference of the present diagram from that of Figure 3 comes from the fact that the image memory 54 receives, at its entry 59, not signal 46 containing the line and column numbers of each pixel, but signal 45 (represented here by 45′, drawn with dots) only containing the line number of the pixel, that is to say, its ordinate y.

The functioning of LUT 52 is the same as that described in Figures 4a and 4c and the principal advantage of this form of execution of the invention is the reduction in the size of the memory (reference 62 in Figure 4c) required to store all the possible values of the transformation h. According to this implementation method of the invention, the same transformation h is applied to an entire line of the image, which still produces a high quality image after treatment since the limits of the treated zones do not appear.

By varying this implementation method of the invention, one could also eliminate module 57 containing the microcontroller or only signal 49 containing parameter p.

In another variation of the invention, calculations of transformation f or h can be made directly in real time (without storing pre-calculated results in a memory) by means of a digital signal processor DSP, but this type of application is more costly.

Obviously, the present invention is not limited to the implementation examples described above but encompasses all variations.

Notably, the storage memory for pre-calculated values of transformation f or h can be constituted of several cases of ROM of low capacity hooked up to address and multiplex circuits which are appropriate, or even it could be constituted of k' cases of 1 bit hooked up in parallel and more generally, it could be constituted of all addressable memory, rapid and capable of storing a table of constants in a permanent manner.

CLAIMS

1- Process for the improvement of night vision, notably for motor vehicles, consisting, by means of a filming system sensitive to visible and non-visible rays, to capture an image of the roadway, illuminated with headlights emitting in the visible and non-visible domains of the spectrum, the said image being constituted of pixels, elementary points each with a gray level, and to apply to the said image a LUT, law of transformation of gray levels, characterized in that at least two different laws of transformation are applied to distinct groups of pixels of the image.

2- Process for the improvement of night vision according to Claim 1, characterized in that the roadway is illuminated, on the one hand, by at least one headlight emitting waves in the visible range of the spectrum and on the other hand, by at least one headlight emitting waves in the infrared range of the spectrum, the filming system equipped with the image capturing means that is sensitive to the visible spectral range and that of infrared.

3- Process for the improvement of night vision according to Claim 1 or 2, characterized in that a specific law of transformation of gray levels is applied to each line of the captured image.

4- Process for the improvement of night vision according to Claim 1 or 2, characterized in that a law of transformation of gray levels is applied to each pixel of the captured image.

5- Process for the improvement of night vision according to any one of Claims 1, 2 or, 4, characterized in that the law of transformation (f) associates, to each gray level g of a pixel of a captured image, a gray level g´ such that:

$$g' = f(g,x,y) = G(x, y)\,(1 - e^{-k(x,\,y)\,g}) \text{ or}$$
$$g' = 1 \text{ if the preceding result is greater than 1,}$$

where x and y are the coordinates of the pixel in the image and where G(x, y) and k (x, y) are parameters characterizing the said transformation and are dependent on coordinates x and y of the pixel in which the above is applied.

6- Process for the improvement of night vision according to any one of Claims 1, 2, or 3, characterized in that the law of transformation (h) associates, to each gray level g of a pixel of the captured image, a gray level g´ such that:

$$g' = h(g, y) = S(y)\,(1- e^{-t(y)\,g}) \text{ or}$$
$$g' = 1 \text{ if the preceding result is greater than 1,}$$

Where S(y) and t(y) are parameters which characterize the transformation h and which are dependent on ordinate y (or line number) of the pixel to which the said transformation is applied.

7- Process for the improvement of night vision according to Claim 5 or 6, characterized in that the law of transformation (f, h) of gray levels is dependent on setting parameter (p), the said parameter being independent of coordinates (x, y) of the pixel to which the said law of transformation (f, h) is applied.

8- Device for the improvement of night vision for the execution of the process according to one of the preceding claims, of a type including a camera (20) equipped with CCD sensors (21) and a piloting module (22) for the said sensors, characterized in that it has a memory (62) containing all the possible values of the law of transformation (f, h) of gray levels, which are predetermined,.

9- Device for the improvement of night vision according to Claim 8, characterized in that the storage address of each value (g'), image through the transformation (h) of a gray level g of a pixel located at coordinates x and y of the image is formed by the concatenation of the following digital signals:
-the gray level (g) of the pixel, and
-the ordinate (y) of the said pixel.

10- Device for the improvement of night vision according to Claim 9, characterized in that the storage address of each value (g') image[3] through the transformation (f) of a gray level (g) of a pixel located at coordinates x and y of the image, integrates in its formation the abscissa (x) of the said pixel.

11- Device for the improvement of night vision according to either Claim 9 or 10, characterized in that the storage address of each value (g'), image through the transformation (f, h) of a gray level (g) of a pixel located at coordinates x and y of the image, integrates in its formation a parameter (p) of the setting of the said transformation.

12- Device for the improvement of night vision according to any one of Claims 8, 9, 10 or 11, characterized in that it includes a line counting circuit delivering the ordinate (y) of the said pixel for each pixel of the image.

13- Device for the improvement of night vision according to Claim 12, characterized in that in addition it includes a column counting circuit delivering, for each pixel of the image, the abscissa (x) of the said pixel.

14- Device for the improvement of night vision according to Claims 8 to 13 on condition of their dependence on Claim 7, characterized in that it has a microcontroller (26 delivering the setting parameter (p) of the transformation (f, h).

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[3] IL Note - There seems to be a problem with the usage of this word in French: when used as a verb or a noun, the sentence is not grammatically correct, nor does it make much sense, there may be an accent missing, similarly in the paragraph below.

Figure Legends[4]:

Fig. 2
Left: Gray level after transformation
Bottom: Initial gray level

Fig. 3
21: Matrix of CCD sensor
24: Analog-digital converter
39a: Line counter
39b: Column counter
51: LUT
26: Microcontroller
54: Image storage memory
8: Image viewing monitor

Fig. 4b
Address
Datum
Number of bits

Fig. 4c:
Memory

Fig. 6:
21:Matrix of CCD sensors
24: Analog-digital converter
39: line counter
52: LUT
26: Microcontroller
54: Image storage memory
Image viewing monitor

[4] IL Note - Please refer to numbered original for all figure legends.

Annex:

Preliminary Research Report

established on the basis of the latest claims submitted before the beginning of the research.

French Republic

National registration 2726144

National Institute of Industrial Property

FA 507961
FR9412781

Documents considered pertinent

Category	Citation of document indicating the interested parties , in case of need	Claims concerning the application under examination
Y	DE-A-40 32 927 (Bosch GMBH Robert) April 30, 1992 **column 2, line 1 -line 52**	1,2
Y	EP-AO 403 268 (Matsushita Electric Industrial Co. Ltd.) December 19, 1990 Column 1, line 53 - line 30 Column 3, line 53 - column4, line 32	1,2 3,4,9,10,12,13
D,A	EP-A_O 454 516 (Renault) October 30, 1991 Column 3 , line 58 - column 4 line 17 Column 4, line 37 - line 48	1,2,8
A	US-A-4 829 381 (Song Woo-Jin et al) May 9, 1989 Column 1. line 15-line 57	1,4,14
A	EP-A_O 363 209 (Marconi GEC Ltd.) April 11, 1990 Column 1, line 26-line 47 Column 2, line 40-column 4, line 8	1,4,7,8,14
A	US-A-4 670 788 (Ozaki Takayuki) June 2, 1987 Column 1, line 53 - line 63 Column 2, line 46 - column 7, line 58	
A	Medical and Biological Engineering and Computing Vol. 27 no. 5, September, 1989, pages 507-512, XP 000046396 Leszczynski KW et al "Digital contrast enhancement for online portal imaging" page 507, right column, line 24- page 508, left column, line 7 Page 508, left column, line 51-right column line 11	1

Research performed on June 30, 1995

Examiner: Wentzel, J.

Categories of cited documents:
X: Particularly pertinent in itself
Y: Particularly pertinent in combination with another document of the same category
A: Pertinent in terms of at least one claim or general technological background
O: Unwritten disclosure
P: Insert
T: Theory or principle forming the basis for the invention
E: Patent document dated earlier than the submission date and was unpublished at the time of submission.
D: Cited in the application
L: Cited for other reasons
&: Member of the same family, corresponding document

JOB 2074(F) A

CERTIFICATION

I, Janet Stewart, hereby declare that I am a professional translator experienced in translating patents and technical publications, and that the foregoing is a true and accurate translation of "Procédé et dispositif d'amélioration de la vision nocturne, notamment pour véhicule automobile" to the best of my knowledge.

Janet Stewart

JANET STEWART